Date: March 23, 2022
To: Nebraska Department of Transportation - Safety Committee
From: Lonnie Burklund, PE, PTOE; Pat Byrd, PE, PTOE
JEO Consulting Group, Inc.
Subject: South Sioux City Signal System - Funding Request

The City of South Sioux City is requesting Federal Highway Safety Improvement Program (HSIP) funding for safety improvements to the signal system infrastructure in South Sioux City, Nebraska.

PROJECT BACKGROUND AND STUDY AREA:

This project was identified through the process of response to inquiries regarding vehicular delay and safety at signalized intersections in South Sioux City. There have been prior requests for operational improvements, in addition to questions regarding signal displays for enhanced visibility due to truck traffic, and other vehicle conflicts at intersections. As such, South Sioux City staff took a proactive approach to further evaluate signalized intersections through the City to look for opportunities to enhance safety and operations along both US Highway 77 Bypass and Dakota Avenue corridors. See Figure 1 for a vicinity map showing the location of the 14 signalized intersections along both the corridors, in addition to the existing signal communications network in the area.

An approach was taken to look at the current crash history along both signalized corridors, conduct a cursory review of operations and signal system infrastructure, and look for opportunities that would reduce crashes and enhance signal infrastructure inclusively for City and NDOT along these roadways. Analysis of benefit-cost ratios based on crash reductions expected to occur with the implementation of improved signal optimization and infrastructure was conducted to identify potential project budgets depending on what B/C ratio threshold would be desired.

US Highway 77 is a four-lane divided highway and has a Federal Functional Classification of "Other Freeways and Expressways". US Highway 77 runs along the west side of South Sioux City until it reaches the 9th Street signalized intersection, where it merges with Dakota Avenue before splitting off to travel north over Veteran's Bridge into Sioux City, Iowa. It has an average daily traffic (ADT) volume between 14,500 and 17,000 vehicles through most of the city, with the highest ADT of 32,755 occurring at the 6th Street/Riverview Drive intersection.

Dakota Avenue is a two-lane north-south street with segments that include a two-way left-turn lane (TWLTL), except for 39th Street and the Interstate 129 westbound off-ramp signalized intersections, where the roadway is a four-lane divided highway. Dakota Avenue has a Federal Functional Classification of "Other Principal Arterial" and carries an ADT between 10,000 to 11,500 vehicles through a majority of the city, with the highest ADT of 13,680 occurring at the 39th Street intersection.

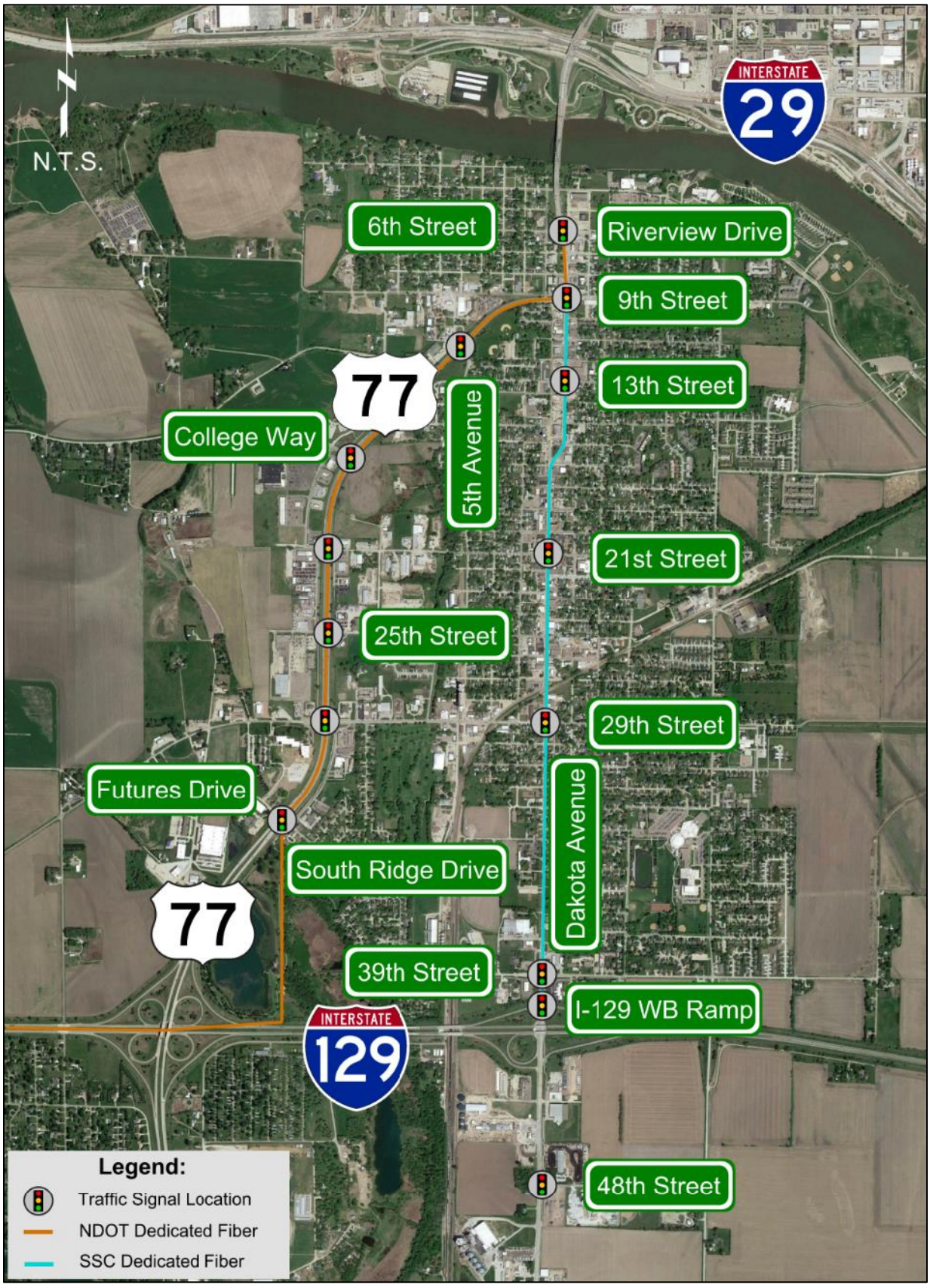

Figure 1. Vicinity Map of South Sioux City

EVALUATION OF SYSTEM:

From January 1, 2018, to December 31, 2021, the 14 signalized intersections located throughout the City of South Sioux City had a total of 318 crashes, including 81 with injuries. There were no fatalities during the crash study timeframe. The US Highway 77 and 6th Street/Riverview Drive and US Highway 77/Dakota Avenue and 9th Street intersections had the highest crash frequency with 63 and 43 crashes in the four-year timeline, respectively. Rear-end crashes are the most common crash type at the study intersections, representing 59% of the multi-vehicle crashes, followed by right-angle crashes at 18%. Additionally, of the 32 left-turn crashes during the study period, a vast majority of them occurred along the US Highway 77 and Dakota Avenue mainline corridors (left-turns from the primary roadway) versus the minor streets. A full summary of multi-vehicle crash types can be found in **Table 1** below, and all crashes by severity in **Table 2** on the following page.

Table 1. Multi-Vehicle Crashes at Signalized Intersections by Crash Type (2018 - 2021)

Intersection	Multi-Vehicle Collision Types							Total Multi-Vehicle Crashes
	Right Angle	Rear End	Sideswipe (Same Direction)	Sideswipe (Opposite Direction)	Head-On	Left-Turn	Other	
Dakota Ave & 48th St	0	6	0	0	0	0	0	**6**
Dakota Ave & I-129 WB Ramp	1	8	1	0	0	3	0	**13**
Dakota Ave & 39th St	3	18	7	0	0	2	0	**30**
Dakota Ave & 29th St	4	34	1	0	0	2	0	**41**
Dakota Ave & 21st St	2	18	1	0	0	1	0	**22**
Dakota Ave & 13th St	5	18	0	0	0	0	0	**23**
US-77/Dakota Ave & 9th St	5	27	7	0	1	3	0	**43**
US-77 & 6th/Riverview Dr	16	31	6	0	1	9	0	**63**
US-77 & 5th Ave	1	1	4	0	0	1	0	**7**
US-77 & College Way	1	4	3	0	0	4	0	**12**
US-77 & 21st St	8	3	2	0	0	6	0	**19**
US-77 & 25th St	2	2	0	0	0	0	0	**4**
US-77 & 29th St	4	8	2	0	0	0	0	**14**
US-77 & Futures Dr/South Ridge Dr	4	2	1	0	0	1	0	**8**
Total	**56**	**180**	**35**	**0**	**2**	**32**	**0**	**305**

NOTE: There were an additional 13 single-vehicle crashes during the crash study timeframe, including 7 with a fixed object, 2 with a pedestrian, 1 with an animal, and 2 of other types.

Table 2. Signalized Intersections by Crash Severity (2018 - 2021)

Intersection	Crash Severity			Total
	Fatal	Injury	PDO	
Dakota Ave & 48th St	0	3	3	**6**
Dakota Ave & I-129 WB Ramp	0	3	10	**13**
Dakota Ave & 39th St	0	4	27	**31**
Dakota Ave & 29th St	0	12	29	**41**
Dakota Ave & 21st St	0	5	19	**24**
Dakota Ave & 13th St	0	7	17	**24**
US-77/Dakota Ave & 9th St	0	5	39	**44**
US-77 & 6th/Riverview Dr	0	19	47	**66**
US-77 & 5th Ave	0	3	7	**10**
US-77 & College Way	0	3	10	**13**
US-77 & 21st St	0	8	12	**20**
US-77 & 25th St	0	2	2	**4**
US-77 & 29th St	0	6	8	**14**
US-77 & Futures Dr/South Ridge Dr	0	1	7	**8**
Total	**0**	**81**	**237**	**318**

PROPOSED IMPROVEMENTS:

Based upon the highest proliferation of crash types, and field review of operations along these corridors, improved signal timing optimization is recommended. Due to the age, condition, and current operational capabilities (phasing and detection) of several intersections, modernized vehicle detection, and signal cabinet equipment are needed at several locations. This would allow for the implementation of improved signal timing and control options that would result in a reduction in stops, crashes, and undesirable operations. According to the Crash Modification Factors (CMF) Clearinghouse website maintained by FHWA, optimizing signal timing, and implementing automated control features (like adaptive) can reduce affected crashes by 13% (CMF = 0.13). Conservatively, the City of South Sioux City assumed a smaller CMF of 0.01 and assumed diminishing benefits every year over 5 years after implementation due to fluctuations in traffic. The upgrade of associated equipment that is needed was assumed to have a minimum lifespan of 15-years before upgrade or replacement. This timeframe is consistent with current products and deployments. Much of the signal system hardware at locations in the City is 2-3 times older than this assumed operational period today. New and updated signal retiming could happen every 5 years on a cyclical basis. However, this analysis conservatively assumed one, initial, signal timing deployment during those 15 years.

Additionally, a vast majority of left-turn movements at each of the study intersections occur under either a three-section signal indication with permissive only control or a five-section indication with protected-permissive control. Updating these signal indications to include a flashing yellow arrow (FYA) provides a significant reduction in left-turn crashes, with the Clearinghouse website providing a CMF for both these three and five-section scenarios. Changing the three-section indication from a green ball with permissive only phasing to a FYA permissive array provides a CMF of 0.502, while the change from a five-section protected-permissive left-turn to a four-section protected-permissive left-turn with a FYA provides a CMF of 0.162. These new signal indications are programmed for a lifespan of 20 years.

BENEFITS OF IMPROVEMENTS:

These proposed improvements would help to effectively reduce the rear end, right-angle, and left-turn crash patterns at each of the 14 signalized intersections. **Table 3** provides an estimated crash cost savings at each intersection, the total savings on both the US Highway 77 and Dakota Avenue corridors, and the total study area.

Table 3. Estimated Crash Cost Savings by Corridor (2022 Dollars)

Dakota Avenue Corridor			
Intersections	Crash Cost Saved from Signal Upgrades & Retiming (5-Year Period)	Crash Cost Saved from Flashing Yellow Arrow (FYA) Upgrades (20-Year Period)	Total Overall Cost Saved
Dakota Ave & 48th St	$0	$0	$0
Dakota Ave & I-129 WB Ramp	$0	$460,600	$460,000
Dakota Ave & 39th St	$199,200	$460,600	$659,800
Dakota Ave & 29th St	$298,700	$460,600	$759,300
Dakota Ave & 21st St	$99,600	$0	$99,600
Dakota Ave & 13th St	$99,600	$0	$99,600
US-77/Dakota Ave & 9th St	$298,700	$460,600	$759,300
US-77 & 6th/Riverview Dr	$398,300	$1,535,200	$1,933,500
Total	**$1,394,100**	**$3,377,600**	**$4,771,700**
US Highway 77 Corridor			
US-77 & 5th Ave	$0	$0	$0
US-77 & College Way	$0	$460,600	$460,000
US-77 & 21st St	$99,600	$3,070,400	$99,600
US-77 & 25th St	$0	$0	$0
US-77 & 29th St	$99,600	$0	$99,600
US-77 & Futures Dr/South Ridge Dr	$0	$0	$0
Total	**$199,200**	**$3,531,000**	**$3,730,200**
	Total Overall Savings from Both Corridors:		**$8,501,900**

PROJECT IDENTIFICATION AND COST:

To implement robust signal timing optimization and enhance signal controller capabilities along the study corridors, opportunities exist to modernize much of the signalized intersection infrastructure. While some intersections will require less work (i.e., they have cabinets and components requiring fewer upgrades) many of the intersections will benefit greatly from the implementation of new detection systems, improved controllers and functionality, communications systems, and cabling/misc. hardware. Installation of FYA for left-turn movements will also improve the safety of the system. In addition, though not quantified in the calculations, it is anticipated that an improvement project will also include pedestrian countdown signal display installations, additional supplemental signal indications (far right heads), signal indication lane alignment, mast arm signing, and other related equipment that can also greatly improve visibility to motorists and improve safety.

An overall project cost is provided in **Table 4**, which indicates the total system upgrade cost for the combined corridors inclusive of design, construction, and operational improvements.

Table 4. Proposed Signal System Costs

Project Component	Component Costs
NEPA / PE	$195,000
Signal Optimization	$84,000
System Hardware	$765,000
Signal Construction	$960,000
Total	**$2,004,000**

Based upon the total proposed benefits and costs as summarized above, this project would have a projected B/C ratio of 4.24 to 1.

BENEFIT TO COST RATIO ANALYSIS:

Using the estimated crash cost savings listed in **Table 3**, different benefit-to-cost ratios for the project were calculated for illustrative purposes. This information is summarized to provide the scale of improvements that could be implemented at various B/C levels, and thus provide planning to include potential project components that could be added to provide qualitative safety benefits and long-term enhancements to the system. **Table 5** summarizes these different benefit-to-cost ratios for the project, indicating that the proposed scale of improvements to both corridors can easily be accommodated at a B/C ratio that justifies implementation.

Table 5. Assumed Benefit-to-Cost Ratio Comparisons

Benefit to Cost (BC) Ratio	Potential Project Budget for:		
	Dakota Avenue Corridor	US Highway 77 Corridor	Both Corridors
5:1 BC Ratio	$954,340	$746,040	**$1,700,380**
4:1 BC Ratio	$1,192,925	$932,550	**$2,125,475**
3:1 BC Ratio	$1,590,567	$1,243,400	**$2,833,967**

The City of South Sioux City is requesting HSIP funding from the NDOT Safety Committee to program and implement this project to improve safety at all signalized intersections in the City.

Attachments:
Attachment A: NDOT Societal Crash Costs (2018)
Attachment B: South Sioux City Crash History and Cost (2018 -2021)
Attachment C: South Sioux City Total Crash Savings Calculations

Attachment A

NDOT Societal Crash Costs (2018)

SOCIETAL COSTS OF NEBRASKA TRAFFIC CRASHES (2018)

	Costs Recommended by FHWA
Fatal Crash	**$11,310,200**
A-Injury Crash	**$655,860**
B-Injury Crash	**$198,760**
C-Injury Crash	**$125,770**
PDO Crash	**$11,920**

MULTI-VEHICLE CRASHES

	URBAN	RURAL
Right Angle Collision	**$100,530**	**$470,530**
Rearend Collision	**$79,700**	**$166,790**
Sideswipe (Same Direction)	**$54,510**	**$140,930**
Sideswipe (Opposite Direction)	**$123,820**	**$779,300**
Head-on Collision	**$374,700**	**$2,763,900**
Left-turn Collision	**$136,480**	**$279,100**
Other Collision	**$28,000**	**$40,050**
Median Entry Only*	**$370,130**	**$229,380**
Median - CMC & CME*	**$796,910**	**$1,540,450**

SINGLE VEHICLE CRASHES

	URBAN	RURAL
Collision with Train	**$439,510**	**$1,473,300**
Collision with Pedestrian	**$577,070**	**$2,041,060**
Collision with Bicycle	**$256,500**	**$1,347,350**
Collision with Animal	**$24,830**	**$35,520**
Collision with Parked Vehicle	**$34,010**	**$69,990**
Collision with Fixed Object	**$160,020**	**$271,690**
Overturn	**$348,300**	**$565,510**
Other Single Vehicle Crash	**$189,400**	**$117,100**
Median Entry Only*	**$196,500**	**$339,450**
Median - CMC & CME*	**$605,870**	**$952,010**

**Costs for Median Related Crashes are from January 1, 2017 to December 31, 2019.*

Recommended costs come from FHWA Report, FHWA-SA-17-071, *Crash Costs for Highway Safety Analysis,* January 2018.

Attachment B

South Sioux City Crash History (2018 - 2021)

South Souix City Crashes - Years 2018 to 2021

Intersection	Crash Type																	
	Multi-Vehicle Collisions								Single Vehicle Collisions									Total Overall Crashes
	Right Angle	Rear End	Sideswipe (Same Dir)	Sideswipe (Opp Dir)	Head-On	Left-Turn	Other	Total MV Crashes	w/ Train	w/ Pedestrian	w/ Bicycle	w/ Animal	w/ Parked Vehicle	w/ Fixed Object	Overturn	Other	Total SV Crashes	
Dakota Ave & 48th St	0	6	0	0	0	0	0	**6**	0	0	0	0	0	0	0	0	**0**	**6**
Dakota Ave & I-129 WB Ramp	1	8	1	0	0	3	0	**13**	0	0	0	0	0	0	0	0	**0**	**13**
Dakota Ave & 39th St	3	18	7	0	0	2	0	**30**	0	0	0	0	0	0	0	1	**1**	**31**
Dakota Ave & 29th St	4	34	1	0	0	2	0	**41**	0	0	0	0	0	0	0	0	**0**	**41**
Dakota Ave & 21st St	2	18	1	0	0	1	0	**22**	0	1	0	0	0	1	0	0	**2**	**24**
Dakota Ave & 13th St	5	18	0	0	0	0	0	**23**	0	0	0	0	0	1	0	0	**1**	**24**
US-77/Dakota Ave & 9th St	5	27	7	0	1	3	0	**43**	0	1	0	0	0	0	0	0	**1**	**44**
US-77 & 6th/Riverview Dr	16	31	6	0	1	9	0	**63**	0	0	0	0	0	2	1	0	**3**	**66**
US-77 & 5th Ave	1	1	4	0	0	1	0	**7**	0	0	0	0	0	3	0	0	**3**	**10**
US-77 & College Way	1	4	3	0	0	4	0	**12**	0	0	0	1	0	0	0	0	**1**	**13**
US-77 & 21st St	8	3	2	0	0	6	0	**19**	0	0	0	0	0	0	0	1	**1**	**20**
US-77 & 25th St	2	2	0	0	0	0	0	**4**	0	0	0	0	0	0	0	0	**0**	**4**
US-77 & 29th St	4	8	2	0	0	0	0	**14**	0	0	0	0	0	0	0	0	**0**	**14**
US-77 & Futures Dr/South Ridge Dr	4	2	1	0	0	1	0	**8**	0	0	0	0	0	0	0	0	**0**	**8**
Total	**56**	**180**	**35**	**0**	**2**	**32**	**0**	**305**	**0**	**2**	**0**	**1**	**0**	**7**	**1**	**2**	**13**	**318**

Intersection	Crash Severity			Total
	Fatal	Injury	PDO	
Dakota Ave & 48th St	0	3	3	**6**
Dakota Ave & I-129 WB Ramp	0	3	10	**13**
Dakota Ave & 39th St	0	4	27	**31**
Dakota Ave & 29th St	0	12	29	**41**
Dakota Ave & 21st St	0	5	19	**24**
Dakota Ave & 13th St	0	7	17	**24**
US-77/Dakota Ave & 9th St	0	5	39	**44**
US-77 & 6th/Riverview Dr	0	19	47	**66**
US-77 & 5th Ave	0	3	7	**10**
US-77 & College Way	0	3	10	**13**
US-77 & 21st St	0	8	12	**20**
US-77 & 25th St	0	2	2	**4**
US-77 & 29th St	0	6	8	**14**
US-77 & Futures Dr/South Ridge Dr	0	1	7	**8**
Total	**0**	**81**	**237**	**318**

Attachment C

South Sioux City Total Crash Savings Calculations

Crash Modification Factors Clearinghouse			
Crash Modification Factor (CMF)	Value	CRF	Used Rate
Install Adaptive Traffic Signal Control	0.87	0.13	0.1
Change from Permissive Only to Flashing Yellow Arrow Permissive Only	0.498	0.502	0.502
Change from 5-Section "Doghouse" Protected/Permissive Left Turn to Flashing Yellow Protected/Permissive Left Turn	0.838	0.162	0.162

South Sioux City Total Crash Saving Calculations (2018-2021)

Crash Costs				
Crash Type	2018 Cost ($)		2021 Cost ($)[3]	Inflation[3]
MV Crash[1]	$88,526		$99,579	1.124864
Left Turn Crash[2]	$136,480		$153,521	1.124864

[1] Unit cost caculated based on cost per multi-vehicle crash type taken from NDOT provided Societal Costs of Nebraska Crashes (2018) and weighted to reflect crash occurances by type within the study area from 2018 to 2021.

[2] Unit cost taken from NDOT provided Societal Costs of Nebraska Crashes (2018) for left-turn crash.

[3] Assumes 4% inflation per year from 2018 to 2021

Dakota Avenue Corridor

Intersection	Crash Data from 2018-2021				Future MV Crashes Saved (5-Year Period)	Total MV Crash Cost Saved (Over 5-Year Period)	Future Left Turn Crashes Saved (20-Year Period)	Total Left Turn Crash Cost Saved (Over 20-Year Period)	Future Left Turn Crashes Saved (20-Year Period)	Total Left Turn Crash Cost Saved (Over 20-Year Period)	Total Left Turn Crash Cost Saved (Over 20-Year Period)	Total Crash Cost Saved (Over 20-Year Period)
	Total MV Crashes (per Year)	Total MV Crash Cost (per Year)	Total Left Turn Crashes (per Year)	Total Left Turn Crash Cost (per Year)								
Dakota Ave & 48th St	2	119550	0	$0	0	$0	0	$0	0	$0	**$0**	**$0**
Dakota Ave & I-129 WB Ramp	3	300520	1	$102,360	0	$0	0	$0	3	$460,564	**$460,564**	**$460,564**
Dakota Ave & 39th St	8	597680	1	$68,240	2	$199,158	0	$0	3	$460,564	**$460,564**	**$659,722**
Dakota Ave & 29th St	10	859847.5	1	$68,240	3	$298,738	0	$0	2	$307,043	**$307,043**	**$605,781**
Dakota Ave & 21st St	6	456662.5	0	$34,120	1	$99,579	0	$0	2	$307,043	**$307,043**	**$406,622**
Dakota Ave & 13th St	6	484312.5	0	$0	1	$99,579	0	$0	2	$307,043	**$307,043**	**$406,622**
US-77/Dakota Ave & 9th St	11	955065	1	$102,360	3	$298,738	0	$0	2	$307,043	**$307,043**	**$605,781**
US-77 & 6th/Riverview Dr	16	1502315	2	$307,080	4	$398,317	6	$921,129	2	$307,043	**$1,228,172**	**$1,626,489**
Total	**62**	**5275952.5**	**6**	**$682,400**	**14**	**$1,394,109**	**6**	**$921,129**	**16**	**$2,456,343**	**$3,377,472**	**$4,771,581**

US Highway 77 Corridor

Intersection	Crash Data from 2018-2021				Future MV Crashes Saved (5-Year Period)	Total MV Crash Cost Saved (Over 5-Year Period)	Future Left Turn Crashes Saved (20-Year Period)	Total Left Turn Crash Cost Saved (Over 20-Year Period)	Future Left Turn Crashes Saved (20-Year Period)	Total Left Turn Crash Cost Saved (Over 20-Year Period)	Total Left Turn Crash Cost Saved (Over 20-Year Period)	Total Crash Cost Saved (Over 20-Year Period)
	Total MV Crashes (per Year)	Total MV Crash Cost (per Year)	Total Left Turn Crashes (per Year)	Total Left Turn Crash Cost (per Year)								
US-77 & 5th Ave	2	133687.5	0	$34,120	0	$0	0	$0	0	$0	**$0**	**$0**
US-77 & College Way	3	282195	1	$136,480	0	$0	0	$0	3	$460,564	**$460,564**	**$460,564**
US-77 & 21st St	5	492810	2	$204,720	1	$99,579	20	$3,070,429	0	$0	**$3,070,429**	**$3,170,008**
US-77 & 25th St	1	90115	0	$0	0	$0	0	$0	0	$0	**$0**	**$0**
US-77 & 29th St	4	287185	0	$0	1	$99,579	0	$0	0	$0	**$0**	**$99,579**
US-77 & Futures Dr/South Ridge Dr	2	188127.5	0	$34,120	0	$0	0	$0	0	$0	**$0**	**$0**
Total	**17**	**1474120**	**3**	**$409,440**	**2**	**$199,158**	**20**	**$3,070,429**	**3**	**$460,564**	**$3,530,993**	**$3,730,151**

Total Savings:	**$8,501,732**
5 to 1	$1,700,346
4 to 1	$2,125,433
3 to 1	$2,833,911